Dual-band Circularly Polarized Monopole Antenna for WLAN Applications

Hao-Shiang Huang and Jui-Han Lu
Department of Electronic Communication Engineering
National Kaohsiung Marine University
Kaohsiung, Taiwan 811

***Abstract*- A novel planar dual-band monopole antenna with circular polarization (CP) operation is proposed. By appropriately introducing dual strip-sleeves shorted at the ground plane, the proposed dual-band CP design can easily be achieved with the impedance bandwidth (RL □10 dB) of about 266 / 980 MHz and the 3 dB axial-ratio (AR) bandwidth of about 103 / 700 MHz for 2.4 / 5.2 GHz wireless local area network (WLAN) applications. The measured peak gain and radiation efficiency are about 4.1 / 3.3 dBic and 94 / 84 % across the operating bands, respectively, with nearly bidirectional patterns in the XZ- and YZ-planes.**

I. INTRODUCTION

Owing to tremendous growth in wireless communication technology, especially for the IEEE 802.11a/b/g WLAN standards in the 2.4 GHz (2400–2484 MHz), 5.2 GHz (5150–5350 MHz) and 5.8 GHz (5725–5825 MHz) bands, the dual-band printed monopole antenna (MA) has attracted high attention because it has the merit of low profile and can provide the feature of multi-band operation. Meanwhile, circularly polarized (CP) antennas can reduce the loss caused by the multi-path effects between the reader and the tag antenna. Several CP monopole antennas have been investigated, such as the annular ring monopole antenna [1, 2], a circular monopole antenna [3], the rectangular patch monopole antenna with a L-shaped slit inset into the ground plane [4, 5], an asymmetrical dipole antenna [6] and an asymmetric-fed rectangular patch monopole antenna with the stub shorted at the ground plane [7]. However, the above mentioned CP antennas are focused on the single-band operation and they have disadvantage of bulky volume [1] or complex structure [2, 3]. Moreover, there is an increasing demand for antennas having more compact size to be suitably embedded in the practical portable devices for multi-input / multi-output (MIMO) system. Therefore, in this article, we propose a novel planar dual-band monopole antenna with circular polarization operation for WLAN communication. By introducing dual asymmetrical strip-sleeves shorted at the ground plane [8] to replace the designs by using the inset slit [2, 4-5], the proposed dual-band CP design can provide the impedance bandwidth (RL □10 dB) of about 266 / 980 MHz and the 3 dB axial-ratio (AR) bandwidth of about 103 / 700 MHz for 2.4 / 5.2 GHz wireless local area network (WLAN) applications, respectively. Good symmetry of bidirectional CP radiation has been observed. Details of the proposed antenna design and experiment results are presented and discussed.

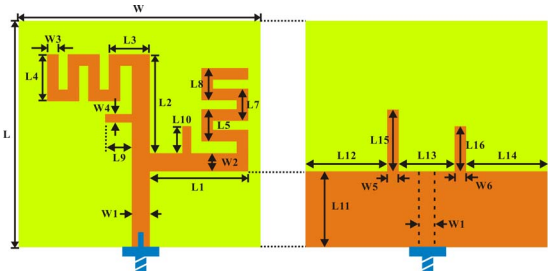
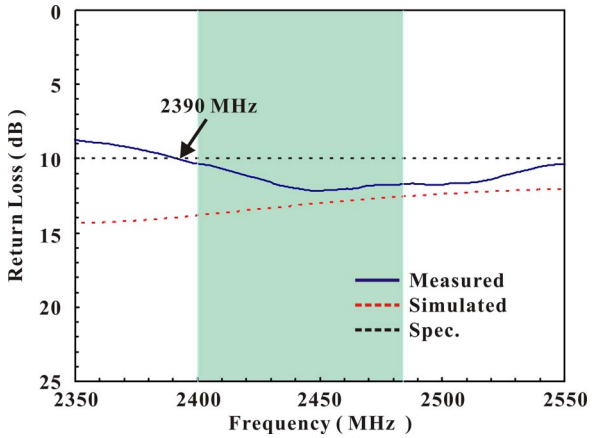


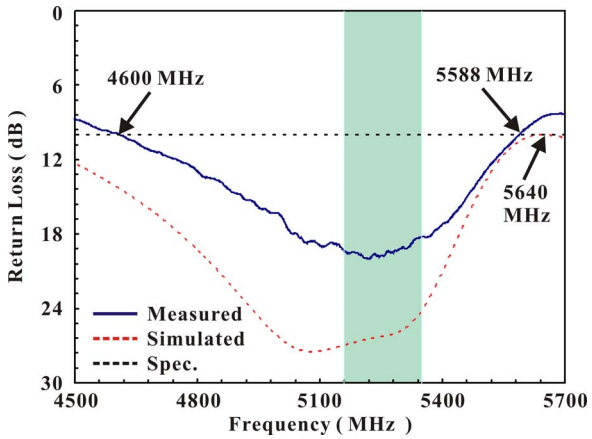
Figure 1. Geometry of the proposed dual-band CP monopole antenna with dual asymmetrical strip-sleeves for WLAN application.

II. ANTENNA DESIGN

Figure 1 illustrates the geometrical configuration of the proposed planar dual-band CP antenna for WLAN application. A 50Ω microstrip line is etched as the feeding structure on the inexpensive FR-4 substrate with the overall volume of 40 × 40 × 0.8 mm^3, dielectric constant $\varepsilon_r = 4.4$ and loss tangent $\tan\delta = 0.0245$. The proposed antenna consists of a pair of orthogonal F-shaped meander monopoles with dual asymetrical strip-sleeves shorted at the ground plane. For compact operation, the longer arm of the F-shaped monopole strip is meandered to obtain less dimension, which is used to generate the fundamental resonant mode at approximately 2450 MHz. The longer strip-sleeve with the dimension of L15 x W5 is introduced to disturb the surface current on the ground plane, which is different from the CP design using the L-shaped slit inset into the ground plane [2, 4-5]. Meanwhile, the right-hand circular polarization (RHCP) can be obtained by exciting the two orthogonal linearly polarized modes with a 90° phase offset, which is due to this proposed strip-sleeve perpendicular to the *x*-directional F-shaped monopole strip. Similarly, The shorter arm of the F-shaped strip is used to generate the fundamental resonant mode at approximately 5200 MHz. The shorter strip-sleeve with the dimension of L16 x W6 is used to excite the left-hand circular polarized (LHCP) wave in the +*z* direction. Moreover, the antenna is optimized based on the above guidelines and by using Ansoft HFSS, a commercially available software package based on the finite element method [9]. Return loss is measured with an Agilent N5230A vector network analyzer.

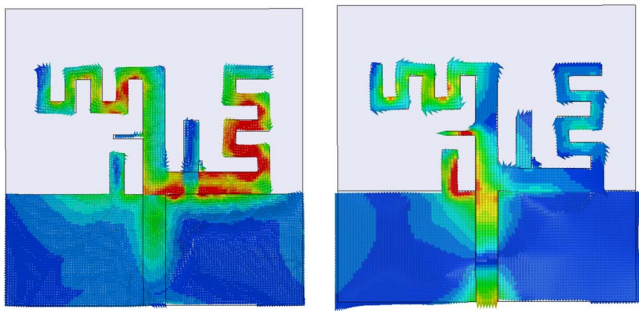


(a) Low band



(b) High band

Figure 2. Simulated and measured return loss against frequency for the proposed compact dual-band CP monopole antenna.

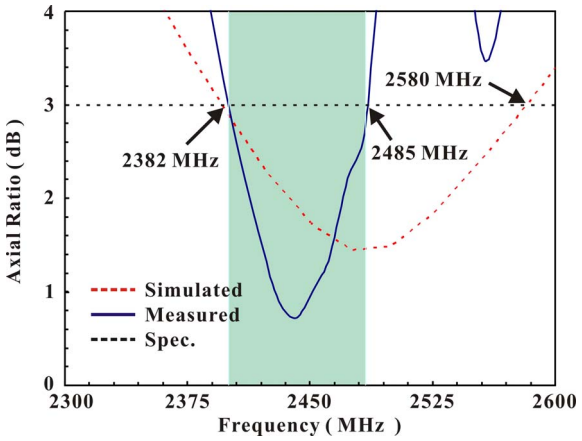


(a) Low band (b) High band

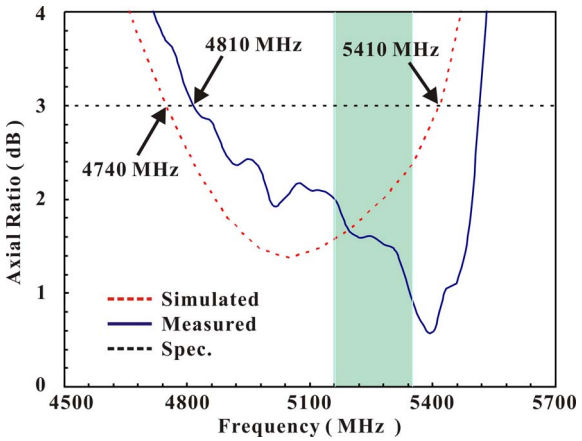
Figure 3. Simulated and measured axial ratio (AR) against frequency for the proposed compact dual-band CP monopole antenna.

III. Results And Discussion

Figure 2 summarizes the simulation and experimental results for return loss in the proposed dual-band CP monopole antenna. The lower band reveals a measured 2:1 VSWR (10-dB return loss) bandwidth of 266 MHz (2400–2660 MHz), whereas the upper band has a bandwidth of 980 MHz (4615–5595 MHz). Dual bands can comply with the bandwidth requirements of the desired dual-band WLAN (2.4/5.2 GHz) application. Figure 3 shows the simulated surface current distributions on the proposed CP antenna at dual operating bands. Figure 4 shows the related simulated and experimental results of the axial ratio (in the boresight direction) for the proposed dual-band CP antenna of Figure 1. From the related results, the measured operating bandwidth (3-dB AR) can reach about 103 MHz (2382–2485 MHz) and 700 MHz (4810–5510 MHz) at 2.4 / 5.2 GHz bands, respectively, and agrees well with the HFSS simulated results. Figure 5 presents the measured antenna gain and efficiency (mismatching loss included, [10]) for the proposed compact printed antenna. This figure also shows the simulation results for comparison. For frequencies over the 2.4 GHz bands, the measured antenna gain is approximately 3.5 ~ 4.1 dBi. Meanwhile, that for the 5.2 GHz band ranges from approximately 2.5 to 3.3 dBi. The measured antenna efficiency is around 91 ~ 94 % over the 2.4 GHz bands, while that over the 5.2 GHz bands is approximately 60 ~ 84 %. The CP radiation patterns measured at 2400/5200 MHz are plotted in Figure 6, and good symmetry of bidirectional radiation has been observed. Results show the coherent agreement between the measured and simulated results. Since a CP monopole antenna radiates a bidirectional wave, the radiation patterns on both sides of the proposed CP monopole antenna are almost the same, in which a contrary circular polarization is produced; the front-side radiates LHCP while the back-side radiates RHCP. By verification, this antenna structure has successfully achieved a cross polarization discrimination of 20 dB on a wide azimuth range.

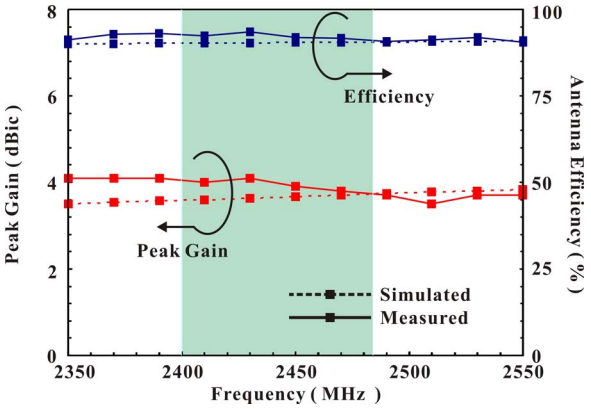


(a) Low band

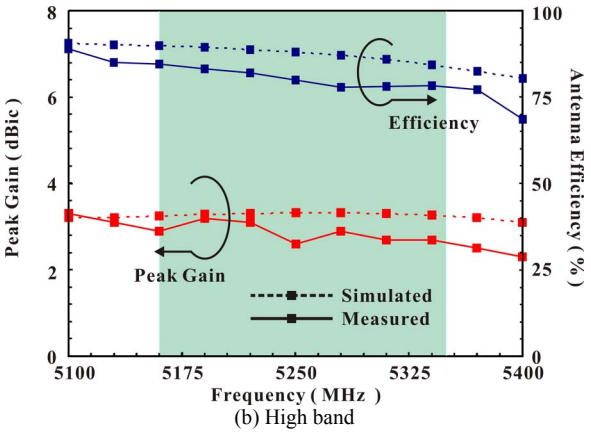


(b) High band

Figure 4. Simulated and measured axial ratio (AR) against frequency for the proposed compact dual-band CP monopole antenna.

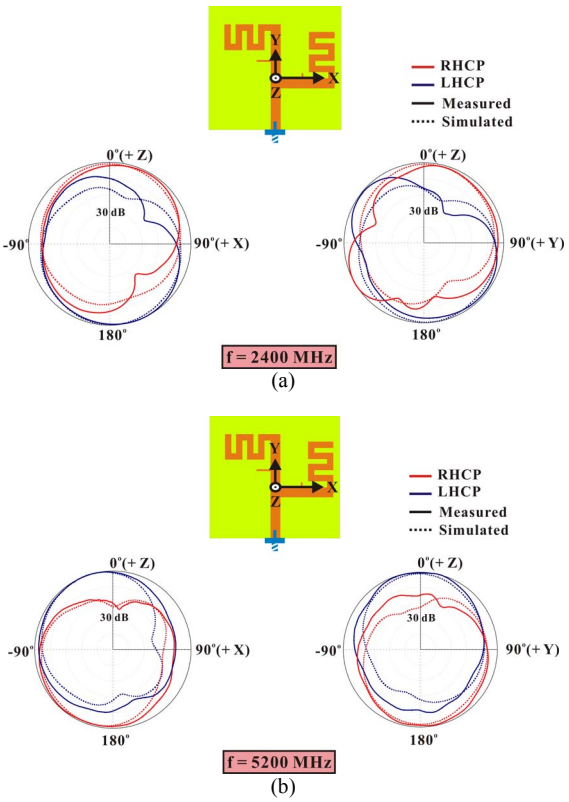


(a) Low band



(b) High band

Figure 5. Measured and simulated antenna gain and efficiency for the proposed compact printed antenna studied in Figure 2.



(a)

(b)

Figure 6. Simulated and measured two-dimensional (2-D) radiation patterns for the proposed compact dual-band CP monopole antenna.

IV. Conclusions

A novel planar compact dual-band circularly polarized monopole antenna is proposed for the application of 2.4 / 5.2 GHz WLAN system. By appropriately introducing dual shorted strip-sleeves on the ground plane, the proposed dual-band CP design can easily be achieved with the impedance bandwidth (RL □10 dB) of about 266 / 980 MHz and the 3 dB axial-ratio (AR) bandwidth of about 103 / 700 MHz for 2.4 / 5.2 GHz wireless local area network (WLAN) applications. The measured peak gain and radiation efficiency are about 4.1 / 3.3 dBic and 94 / 84 % across the operating band, respectively, with nearly bidirectional pattern in the XZ- and YZ-plane.

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